Smart Sensor Systems 2005

April 25 - 28, 2005
Delft, The Netherlands

General information about the course

Lectures are given by top experts from universities and industries. The prerequisite for the course is a basic knowledge of electrical circuits and systems. Course will be taught in English. Each attendee will receive a certificate of attendance at the course.

Short description

Recent developments in the field of smart sensor systems are reviewed. After a general overview system details are discussed, concerning: sensor principles, tandem transducers, smart analog interfaces, modifiers, A/D conversion, busses and digital interfaces, DSPs and microcontrollers. A systematic approach towards the design of smart sensor systems is presented. The lectures include case studies and hands-on demonstrations.

Location

The course will be held at the Faculty of Electrical Engineering, Mathematics and Computer Science, Mekelweg 4, Jan Anthony Snijderszaal, room LB1.010 of Delft University of Technology, The Netherlands.

Access to TU Delft

1.From Amsterdam Airport (Schiphol)
a) by train to Delft Central Station (approx. 50 min.)
b) by highway A4 (Den Haag) - A13 (Delft, Rotterdam)

2.From Rotterdam Airport
a) by taxi (10 min.)
b) by highway A13 (10 km.)

3.From Rotterdam Central Station
a) by railway to Delft Central Station (20 min.)
b) taxi (20 min.)
c) highway A13 (20 km.)

Accommodation

Enclosed you find a list with advised hotels. Please make your hotel booking as early as possible.

Registration fees

Academics : Eur 1250
Industry : Eur 1550
Included in the fee are lecture notes, daily lunches, coffee breaks and course dinner on tuesday organized for all attendees and instructors of the course.

Registration form containing course registration should be returned to the mailing address before the deadline for registration, March 20, 2005.

Liability

Delft University of Technology is not liable for lost or damage to participants property.

Course organization:

This course is organized by:
Delft Institute of Microelectronics and Submicron Technology (DIMES)
Delft University of Technology
Delft, The Netherlands

Web page:
http://ei.ewi.tudelft.nl

Organizers:
Course directors:
G.C.M. Meijer, TU Delft
J.H. Huijsing, TU Delft

Secretary:
Trudie Houweling
Delft University of Technology, Faculty of EEMCS
Laboratory for Electronic Instrumentation
Mekelweg 4
2628 CD Delft
The Netherlands
g.houweling@ewi.tudelft.nl

Smart sensor systems, programme 2005

Introduction and overview

Monday, April 25	Lecture / Activity	Lecturer	Location
09.30 -10.00	Receipt + coffee		LB1.010
10.00 -10.30	**1.** Introduction to the course programme	G.C.M. Meijer	
10.30 - 10.45	Welcome and opening speech	J.H. Huijsing	
10.45 -11.30	**2.** Where and how to apply smart sensor systems	J.H. Huijsing	
11.30 -11.45	Coffee break		
11.45 -12.45	**3.** Measurement techniques for smart sensor systems	G.C.M. Meijer	
12.45 -14.00	Lunch		Electron
14.00 -15.00	**4.** Discussions and demonstrations of smart sensor systems, 2 x 30 minutes	4.1 D. Tanase 4.2 R. Aguilar	13th floor
15.00 -15.15	Coffee break		
15.15 -16.00	**5a.** Visit to Dimes Technology Center (DTC), first group	**5b.** Introduction research programme electronics labs, second group	
16.00 -16.45	**6a.** Visit to Dimes Technology Center (DTC), second group	**6b.** Introduction research programme electronics labs, first group	

Sensor elements and tandem transducers

Tuesday, April 26			
08.45 -09.00	Coffee time		LB1.010
09.00 -10.00	**7.** Silicon sensors: an introduction	P.J. French	
10.00 -10.15	Coffee break		
10.15 -11.15	**8.** Physical chemosensors	M.J. Vellekoop	
11.15 -11.30	Coffee break		
11.30 -12.30	**9.** Integr. Hall Magnetic Sensors	P. Kejik	
12.30 -14.00	Lunch		Electron
14.00 –14.45	**10.** Capacitive sensors	X. Li	LB1.010
14.45 -15.00	Coffee break		
15.00 -16.00	**11.** Opto-Electro-Mechanical MicroSystems	G. Vdovin	
16.00 -16.15	Coffee break		
16.15 -17.15	**12.** Smart temperature sensors	G.C.M. Meijer	
19.00	**Dinner**	Everybody	

Interfaces, busses and systems

Wednesday, April 27			
08.45 -09.00	Coffee time		
09.00 -10.00	**13.** Interface electronics and A/D converters	F.R. Riedijk	
10.00 -10.15	Coffee break		LB1.010
10.15 -11.15	**14.** Sensor busses	F.R. Riedijk	
11.15 -11.30	Coffee break		
11.30 -12.15	**15.** Calibration	M.A.P. Pertijs	
12.15 -14.00	Lunch		Electron
14.00 -17.00	**16.** Hands-on demonstrations	R. Aguilar, X. Li, H.M.M. Kerkvliet, G. Wang, A. Kerezov	

Sensor systems and applications

Thursday, April 28			
08.45 – 09.00	Coffee		
09.00 – 10.00	**17.** Microcontrollers and Digital Signal Processors	R.M. Ivanov	
10.00 – 10.15	Coffee break		
10.15 – 11.15	**18.** Universal asynchronous sensor interfaces	G.C.M. Meijer	
11.15 – 11.30	Coffee break		
11.30 – 12.30	**19.** Dynamic-offset-cancellation techniques	K.A.A. Makinwa	
12.30 -14.00	Lunch		Electron
14.00 - 14.45	**20.** Solar modules in the photovoltaic industry	P.C. de Jong	
14.45 - 15.00	Coffee break		
15.00 - 15.45	**21.** Sensor systems in their environment	R. de Boer	LB1.010
15.45 – 16.30	**22.** Free and interactive programme		
16.30 – 17.00	**23.** Closing Session	J.H. Huijsing, G.C.M. Meijer	

Contents of the course

2. Where and How to Apply Smart Sensor Systems
Johan H. Huijsing, TU Delft

This lecture explains the need for non-expensive smart sensor systems for application in industrial production machines and consumer appliances.
Smart sensor systems will lead to a third automation revolution. After the mechanization and information, “sensoration” will lead to full self-operating production means and consumer appliances. One will be able to tell his car to bring him to work in the morning and the car will do so, while the one being transported can read the newspaper in paper or on Internet.

3. Measurement techniques for smart sensor systems
Gerard C.M. Meijer, TU Delft

The architecture and design of low-cost high-performance sensor systems is reviewed. The sensor systems consist of a number of multiplexed sensor elements, sensor-specific front-ends modifiers and microcontrollers or DSPs. Important design targets are: a high accuracy, a high dynamic range, a high speed, low power consumption, an excellent reliability and low costs. It is shown that A/D conversion can be implemented in the microcontroller or DSP.

7. Silicon sensors: an introduction
Paddy French, TU Delft

In general, a sensor as a device forms the interface between the physical and chemical world to the electrical domain. The five measurand domains are: thermal, magnetic, mechanical, radiant, chemical. Silicon technology has made considerable advances in recent years and this is leading to increasing possibilities for silicon sensors. Silicon does not always make the best sensing element, but the possibility of integrating with electronics in a single device presents many advantages over the traditional approach. This lecture will give a general introduction to sensors and sensor principles leading to the sensor possibilities using silicon technology.

8. Physical chemosensors
Michael Vellekoop, Vienna University of Technology, Austria

The measurement of fluid properties, for example in the production of chemicals and medicine, is of high societal and economic relevance. The research efforts in the field of fluid (chemo)sensors are significant. Some of the typical problems of chemosensors are the fabrication of a reproducible and stable chemical-active interface, and reducing the effects of aging, clogging and contamination of the interface. By applying measurement methods based on physical effects instead of on chemical effects, the above-mentioned problems can be circumvented. The miniaturization of analysis systems by silicon integration yields other advantages such as high-speed handling and low costs. By adding integrated electronics, the functionality of the system can be enhanced to meet the required specifications (e.g. auto-calibration or compensation). Examples of integrated systems that will be discussed are nanoliter arrays for high-speed screening (HSS), gas chromatograph thermal detectors, a multiparameter sensor system for oil condition monitoring, liquid conductivity detection in ion separators, and optical

particle detectors. Also, developments in particle separation and sorting based on dielectrophoresis will be discussed. Developments in wafer-bonding technology will be described as an example of newly developed technology for the fabrication of microsensors and -actuators in microchannels.

9. Integrated Hall magnetic sensors

Pavel Kejik, EPFL, Lausanne, Switzerland

The lecture starts with a brief introduction into the Hall effect and Hall elements. Then the problems and good practices in the realization of integrated Hall magnetic sensors will be reviewed. The main issues are offset, temperature cross-sensitivity, switching noise, and drift related to the packaging stress. By combining Hall elements with well-adapted interface electronics some of the problems can be dramatically reduced. It will be shown that integration of magnetic flux concentrators on the sensor chip will further decrease the equivalent magnetic noise and offset.

10. Capacitive Sensors

Xiujun Li, TU Delft

A systematic approach towards the design of reliable smart low-cost high-performance capacitive sensors is presented. The basis problems and their solutions of both the physical and the electrical signal processing are discussed. The examples concern capacitive sensors in position detectors, liquid-level detectors and personnel detectors.

11. Opto-Electro-Mechanical MicroSystems (MOEMS)

Gleb Vdovin, TUDelft

The course will give an introduction to the principles and technology of micro-opto- electro-mechanical systems. Revolutionary development of the field in the last decade was fueled by the availability of novel micro-scale fabrication opportunities for optics and mechanics. These technologies include surface and bulk silicon micromachining, LIGA, high-resolution optical lithography and computer-generated refractive and diffractive micro-optics.
Combination of these technologies with more traditional integrated electronics resulted in a whole new field of research and, since recently, commercial development, combining electronics mechanics and optics in the uniform technological framework. In the second part of the lecture, the most recent successful MOEMS implementations will be considered, including: 1) a massive multichannel fiber optical switch for optical networks, 2) a micromachined adaptive optical system for correction of the image quality and ultrafast optics, 3) the Texas Instruments DLP (Digital Light Processing) technology.

12. Smart temperature sensors

Gerard Meijer, TU Delft

An overview of existing temperature sensors will be given. Specific advantages and disadvantages will be discussed. Special attention will be given to the architecture and performance of integrated temperature sensors. As a result of the ongoing computerization and reduction of IC-costs these sensors have a

rapidly growing market. Some case studies of integrated sensors in practical applications will be presented.

13/14. Interface electronics and busses

Frank Riedijk, Xensor Integration, Delfgauw

The lecture will review the most important developments in smart-sensor interface technology and the applied transmission methods. Especially A/D conversion technology, such as duty-cycle and sigma-delta conversion and communication trends on sensor-component level will be highlighted. Examples of the applied techniques in today's products will be presented.

15. Calibration

Michiel A.P. Pertijs, TU Delft

This lecture introduces the concepts of calibration, trimming, and self-calibration in the context of smart sensors. The role of calibration in defining the accuracy of a smart sensor will be discussed. The trade-off between guaranteeing accuracy by calibration and by design will be illustrated using a smart temperature sensor. Various interpretations of the term 'self-calibration' will be discussed. The concept of a self-calibrating sensactor (a combination of a sensor and actuator) will be illustrated using a smart wind sensor and a Hall sensor.

16. Hands-on Demonstrations

Rolando Aguilar, Guijie Wang, Harry M.M. Kerkvliet, Xiujun Li, TU Delft and Alexander Kerezov, TU Sofia

About 15 demonstrations (μC + PC based) will be available in the hands-on midday. Assisted by instructors, the participants will play with each demonstration. Questions can be raised and discussed during the hands-on activity.

The demonstrations include: Smart temperature measurement systems, temperature control systems, ethernet sensor systems, smart sensor systems applying universal transducer interfaces for rapid prototyping, a capacitive humidity measurement system, a capacitive liquid-level detector, a resistive pressure measurement system, multiple-sensor systems, magnetic angular encoders.

17. Microcontrollers and Digital Signal Processors

R.M. Ivanov, Technical University Sofia, Bulgaria

The lecture will give a general introduction and present the features of Microcontrollers (MCUs) and Digital Signal Processors (DSPs) when applied in smart sensors system. The specific requirements for MCUs and DSPs as part of low-cost smart sensor systems will be outlined. A brief introduction to MCUs and DSPs will be given: Architectures, Central Processing Unit (CPU), On-chip Flash and RAM memory, Digital I/O ports, Digital Peripherals (timers and event manager), Analog Peripherals (Comparator, ADC and DAC). Also some specific MCUs and DSPs will be discussed, such as PIC16F87x, ADuC824, MSP430 and TMS320LF240xA. Integrated development environments for MCUs and DSPs as support to complete in-system design will be noted. Key questions will be answered: How to select the best MCU or DSP for your sensor application? How

and from where to get more information? The lecture will be illustrated with practical examples and demonstrations.

18. Universal asynchronous sensor interfaces

Gerard Meijer, TU Delft

In this lecture it is shown that relaxation oscillators are very suited to be applied as modifiers for many types of sensor signals at their input. The modulated output signals can directly be read out by microcontrollers and DSPs.
To connect different types of sensing elements at the modulator input different types of sensor-specific front-ends are required. The features of the overall systems are discussed for capacitive and resistive (bridge) transducers.

19. Dynamic offset-cancellation techniques

Kofi A. A. Makinwa, TU Delft

An introduction to dynamic-offset-cancellation techniques will be given. It will be shown that, in combination with smart sensor interfaces, new topologies can be developed which have less offset and noise than existing solutions. A smart spinning-current Hall plate interface will be shown which has sub-μV input offset. Also shown, will be a precision comparator for use in a thermal sigma-delta modulator with less than 10 μV offset.

20. Solar modules in the photovoltaic industry

Paul C. de Jong, ECN, Petten

It is shown how solar modules work, and how to design photovoltaic transducers (solar cells) with silicon as a substrate material.. The systematic design of solar modules will be addressed by reviewing several interconnection and encapsulation techniques in order to achieve module lifetimes of 25 years under normal outdoor conditions. Several examples of traditional and future technologies will be presented.

21. Sensor systems in their envronment

Rolf de Boer, Smartec BV., Breda

In 1989 Smartec started to produce smart temperature sensors. At that time industry was not ready to use these novel devices in their products. The lecture will review the difficulties encountered and the problems which had to be solved. Based on these experiences predictions for the future development will be presented.

Biographies of the lecturers

Rolando Aguilar

Rolando Aguilar was born in Chile in 1972. He received the Electrical Civil Engineer degree from Magallanes University, Punta Arenas, Chile in 1998. From 2000 he jointed the Electronic Instrumentation Laboratory following a master programme. From September 2001 he has been involved in research on "human-interface" for art applications.

Rolf de Boer

Rolf de Boer was born in the Netherlands in 1947. He received the M.S. degree in physical engineering from Delft University of Technology, Delft, The Netherlands in 1977. From 1981-1989 he was head of the research department of the company KIPP & Zn., Delft, the Netherlands. In 1989 he was one of the founders of the company Smartec, where he is the general director. Smartec is a producer of smart sensor devices and systems.

Paddy French

Paddy French received his B.Sc. in mathematics and M.Sc. in electronics from Southampton University, UK, in 1981 and 1982, respectively. In 1986 he obtained his Ph.D., also from Southampton University, which was a study of the piezoresistive effect in polysilicon. After 18 months as a post-doc at Delft University, The Netherlands, he moved to Japan in 1988. For 3 years he worked on sensors for automotives at Central Engineering Laboratories of Nissan Motor Company. He returned to Delft University in May 1991 were he has been involved in research on micromachining and process optimization related to sensors. Since 2002 he is chairing the Laboratory for Electronic Instrumentation. In 1999 he was awarded the Anthony van Leeuwenhoek chair. He received the title award of "Simon Stevin Meester" from the Dutch Technology Foundation.

Johan Huijsing

Johan H. Huijsing was born in Bandung, Indonesia, on May 21, 1938. He received his M.Sc. in Electrical Engineering from Delft University of Technology, Delft, The Netherlands, in 1969, and his Ph.D. from the same University in 1981 for work on operational amplifiers. Since 1969 he has been a member of the Research and Teaching Staff of the Electronic Instrumentation Laboratory, Department of Electrical Engineering, Delft University of Technology, where he became a full Professor of Electronic Instrumentation since 1990, and professor-emeritus since 2003. He teaches courses on Electrical Measurement Techniques, Electronic Instrumentation, Operational Amplifiers and Analog-to-digital Converters. His field of research is Analog Circuit Design (operational amplifiers, analog multipliers, etc.) and Integrated Smart Sensors. He is fellow of IEEE. He received the title award of "Simon Stevin Meester" from the Dutch Technology Foundation.

Ratcho M. Ivanov

Ratcho Ivanov was born in v.Razliv, Bulgaria on December 25, 1945. He received his M.Sc in Electronics engineering from Technical University, Sofia, Bulgaria in 1969. Since 1970, he has been employed as assistant professor. From 1975 to 1977 he specialized on Microprocessor-based systems in Tokyo Institute of Technology, Japan. In 1980 he obtained his Ph.D from Technical University, Sofia. From 1986 he was associate professor and from 2000 a full professor in Technical University, Sofia, Bulgaria. He has over 25 years of experience in teaching, design, development and implementation of embedded systems, microcontroller and microprocessor based industrial systems, smart sensors systems and applications. He is a senior member of IEEE.

Paul de Jong

Paul C. de Jong was born in Nieuwkoop, The Netherlands, on May 13, 1967.
He received the ingenieurs (M.S.) degree in electrical engineering from Delft University of Technology, Delft, The Netherlands, in 1990, and the PhD degree from the same university in 1998. In 1990 he joined Schlumberger, Clamart, France and Houston, TX, USA, where he was involved with high-temperature electronics for down-hole applications. In 1992 he joined the Laboratory of Electronics, Delft University of Technology, for a research project in high-temperature sensor electronics. In 1998 he joined TNO, The Hague, The Netherlands, working and leading several mechatronics projects. In 2001 he joined Xensor Integration, Delft, The Netherlands where he was involved in research and development of integrated smart sensor systems. Since 2004, he is employed by ECN where he is groupleader of solar energy (PV) module technology.

Pavel Kejik

Pavel Kejik was born in the Czech Republic in 1971. He received the diploma degree in 1994 and the Ph.D. degree in 1999 at the Czech Technical University of Prague. In 1999, he joined the Institute of Microelectronics and Microsystems at the EPFL to work on Institute's circuit design and testing. His research interests include fluxgate magnetometry and micro-Hall sensors combined with mixed-signal IC design and low-noise circuit design for industrial applications.

Alexander Kerezov

Alexander Kerezov was born in Karlovo, Bulgaria on March 18, 1968. He received his M.Sc. in electronics engineering from Technical University, Sofia, Bulgaria in 1993. From 1993 to 1995 he has been a researcher in Istituto di Fisiologia Clinica, C.N.R. - Pisa, Italy in the field of Real time digital signal processing. Since March 1996, he has been employed as assistance professor at the Department of Electronics, Sofia Technical University, where he is involved in research, development lecturing activities in the field of microcontrollers, digital signal processing and embedded systems.

Harry Kerkvliet

Harry M.M. Kerkvliet was born in Voorburg, The Netherlands, on March 18,1945. He graduated in electronic engineering at Royal Polytechnic Institute PBNA, Arnhem, The Netherlands, in 1974. From 1977-1987 he was a teacher in Electronics for evening classes at the Intermediate Technical School. In 1964 he

joined the Department of Electrical Engineering of Delft University of Technology and was involved in areas of television-signal-processing techniques and electronic-system design. His current interests include signal processing and smart sensor systems.

Xiujun Li

Xiujun Li was born in Tianjin, China on February 19, 1963. He received his B.Sc. in physics and M.Sc. in electrical engineering from Nankai University, Tianjin, China in 1983 and 1986, respectively. In 1997, he received his Ph.D. degree from Department of Electrical Engineering, Delft University of Technology, The Netherlands. Since September 1996, he has been employed as assistance researcher at the Faculty of Electrical Engineering, Mathematics and Computer Science, Delft University of Technology, where he was involved in research and the development of smart capacitive sensors and low-cost interfaces for smart sensors. Since 1997 he worked in part time for SMARTEC B.V. on smart temperature sensors and smart sensor interfaces. In 2002 he joined Bradford engineering B.V., Heerle, The Netherlands, where is performs research and development of instruments for the Space Industry.

Kofi Makinwa

Kofi Makinwa was born in Accra, Ghana on April 3rd 1964. He studied at the Obafemi Awolowo University, Ile-Ife, Nigeria where he received a B.Sc. degree (1st class hons.) in 1985 and an M.Sc. degree in 1988, both in Electronic Engineering. He then proceeded to the Philips International Institute, Eindhoven, The Netherlands, where he received an M.E.E. degree (with distinction) in 1989. He began his working career in 1989 as a research scientist at Philips Research Laboratories in Eindhoven, a position he held till 1999. During this period he developed electronic systems for interactive displays, and for optical and magnetic storage systems. He is currently at Delft University of Technology, Delft, The Netherlands, where he is working towards a Ph.D. on 2-D thermal flow sensors. He holds nine patents.

Gerard Meijer

Gerard C.M. Meijer was born in Wateringen, The Netherlands, on June 28, 1945. He received the ingenieurs (M.S.) and Ph.D. degrees in electrical engineering from the Delft University of Technology, Delft, The Netherlands, in 1972 and 1982, respectively. Since 1972 he has been a member of the Research and Teaching staff of the Faculty of Electrical Engineering, Delft University of Technology, where he was engaged in research and teaching on analog ICs and smart sensor systems. Since 2001 he is a full professor of the Laboratory of Electronic Instrumentation of the same university. In 1984 and part-time during 1985-1987, he was seconded to the Delft Instruments Company in Delft, where he was involved in the development of industrial level gauges and temperature transducers. In 1996 he co-founded the company SensArt, where he is a consultant in the field of sensor systems. He received the title award of “Simon Stevin Meester” from the Dutch Technology Foundation.

Michiel Pertijs

Michiel Pertijs was born in Roosendaal, The Netherlands, on May 31, 1977. He received the M.Sc. degree in electrical engineering (cum laude) from Delft University Technology in 2000. He is currently working towards a Ph.D. degree

at the Electronic Instrumentation Laboratory of the same university, on the subject of high-accuracy CMOS smart temperature sensors. In 2000, he worked for Philips Semiconductors, Sunnyvale, California, on circuit design for a smart temperature sensor. From 1997 to 1999 he worked part-time for EARS B.V., Delft, The Netherlands, on the production and development of a handheld photosynthesis meter. His research interests include analog and mixed-signal interface electronics and smart sensors.

Frank Riedijk

Frank R. Riedijk was born in Delft, The Netherlands, on March 23, 1965. He received his M.Sc Degree in 1988 from the Delft University of Technology and the Ph.D degree from the same university in 1993 for work on smart sensors with bus interface. In 1997 he founded the company smart sensor devices, now merged into Xensor Integration, where he is active in high tech sensor projects, such as integrated fingerprint sensors for portable telephones and space data acquisition ASICS. In these fields he is the holder of 5 patents.

Gleb Vdovin

Gleb Vdovin is an Associate Professor at the Faculty of Electrical Engineering, Mathematics and Computer Science of TU Delft. He received his MSc degree in Optical Engineering from the Leningrad Institute of Fine Mechanics and Optics in 1986 and his Ph.D. from TU Delft in 1996. He worked for the soviet space programme from 1986 to 1989 and at General Physics Institute of the Russian Academy of Sciences from 1989 to 1993. Since 1993 he is with TU Delft. His current research includes micromachined and liquid crystal adaptive optics, projection displays, computer simulation of optical systems and integrated imagers. Gleb Vdovin is also involved with Flexible Optical BV – http://okotech.com - the producer of micromachined deformable mirrors and wavefront sensors.

Michael Vellekoop

Michael J. Vellekoop was born in Amsterdam in 1960. He received the B.Sc. degree in Physics in 1982 and the Ph.D. degree in Electrical Engineering in 1994. In 1988 he co-founded Xensor Integration B.V. where he was managing director until 1996. In that year he initiated a new group on the topic of physical chemosensors at the DIMES Electronic Instrumentation Laboratory of the Delft University of Technology, where in 1997 he became an associated professor. Since 2001 he is a full professor of Industrial Sensor Systems at the Institute of Sensor and Actuator Systems at the Vienna University of Technology, Austria. In 2002 he became head of this Institute. Keywords of research are physical chemosensors, physical biosensors, sensor systems, lab on a chip, micro & nanofluidics, micro & nanotechnology.

Guijie Wang

Guijie Wang was born in HeNan, China, on December 10, 1963. She received the M.Sc. degree in electrical engineering from NanKai University in Tianjin, China. Now she is working in Delft University of Technology, the Netherlands, for the Ph.D. degree. Her current interests are in the field of analog integrated circuits.

List of advised Hotels

- Hotel Juliana (€ 78)
  Maerten Trompstraat 33, 2628 RC Delft
  Phone: +31 15 256 7612
  Fax: +31 15 256 5707
  http://www.hoteljuliana.nl

- Hotel Leeuwenbrug (€ 75 mention TU Delft)
  Koornmarkt 16, 2611 EE Delft
  Phone: +31 15 214 7741
  Fax: +31 15 215 9759
  http://www.leeuwenbrug.nl

- Hotel Johannes Vermeer (€ 112)
  Molslaan 18-22, 2611 RM Delft
  Phone: +31 15 212 6466
  Fax: 31 151 213 4835
  http://www.hotelvermeer.nl

- Hotel De Ark (€ 100)
  Koornmarkt 65, 2611 EC Delft
  Phone: +31 15 215 7999
  Fax: +31 15 215 7997
  http://www.deark.nl

- Dutch Hotel Delft (€ 80)
  Kanaalweg 3, 2628 EB Delft
  Phone: +31 15 256 9358
  Fax: +31 15 262 3546
  http://www.dishhoteldelft.nl

Rates are per day for a single room with shower/toilet, including breakfast.
Excluding visitors tax € 2,00 per day.